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THE DIRECTOR OF CENTRAL INTELLIGENCE

Deputy Director for National Foreign Assessment

23 September 1981

NOTE FOR: [redacted] OPA
OSWR

25X1

FROM: [redacted]
Special Assistant for Nuclear Proliferation Intelligence

25X1

SUBJECT: Request for Review of "Report on the Implementation of IAEA Safeguards"

I would appreciate having your written comments on the attached memorandum by COB Friday, 25 September, in preparation for a general discussion that I will be arranging for next week with Harry Rowen (and possibly the DCI).

[redacted]

25X1

Attachment:
As Stated

cc: H. Rowen

DOE review completed.

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE COMMISSIONER

SECRET

August 26, 1981

MEMORANDUM FOR HENRY S. ROWEN
CHAIRMAN, NATIONAL INTELLIGENCE COUNCIL
CENTRAL INTELLIGENCE AGENCY

Harry,

The attached memorandum, prepared at my request, raises very serious questions about the ability of the IAEA safeguards system to detect diversions. I have asked the NRC staff to review the memorandum and examine its implications. I expect you will want to have your staff review it as well.

The classification of the attached memorandum, which was assigned by the NRC staff, points up the problem we face in getting a clear picture of the implementation of the IAEA safeguards system.

Victor Gilinsky
Commissioner

Attachment

Memorandum also sent to:
Richard T. Kennedy, DOS
James Malone, DOS
Paul Wolfowitz, DOS
Fred C. Ikle, DOD
Harold Bengelsdorf, DOE
Louis V. Nosenzo, ACDA

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(ENTIRE TEXT)

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This document consists of 11 pages
No. 4 of 7 copies, Series B

REPORT ON THE IMPLEMENTATION OF IAEA SAFEGUARDS

1. INTRODUCTION

The purpose of this report is to provide an inspector's insight into IAEA safeguards, based upon 7 years as a domestic safeguards inspector with the U.S. Atomic Energy Commission's Division of Nuclear Materials Safeguards and the successors of that organization in the AEC and NRC, 3 years as an international safeguards inspector with the IAEA, and, in addition, several years as an NRC headquarters staff member.

The concept has been advanced at high levels that a country's signature of the NPT is the principle aim of IAEA safeguards. This report is only concerned with the technical aspects of IAEA safeguards inspection activities, and does not address such broad issues.

The concept has also been advanced that IAEA safeguards are of more value than is apparent by virtue of their technical value per sé. This may be true where a State does not understand the means by which safeguards are applied. In my experience, the representatives of the state systems and the operators of the installations know exactly how effective international safeguards are and how the international safeguards system can be defeated. I can only address the technical capability to safeguard nuclear materials.

2. ORGANIZATION OF IAEA

The Board of Governors of the IAEA, on which 34 States are represented, is the principal authority which influences the policy of the Agency. Voting is on a one-member one-vote basis, so that less populous countries have as much influence as more populous ones. In terms of budget, however, a large proportion of funding is provided by the U.S., and the U.S. also provides additional monies and technical assistance to the Agency.

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The Agency's Inspectorate is very responsive to concerns of the countries which it inspects. A complaint via the Board of Governors can end or alter the career of an Agency employee. Thus, the Inspectorate is controlled by the Inspected. A "diplomacy above all else" or "don't push your luck" mentality prevails.

Another point of interest about the IAEA organization in the Department of Safeguards is that nationals of the country inspected have access to inspection reports, seals, seal records, etc., that concern their own countries. For example, I once had to explain a report that I had written to an individual responsible for clearing it from the country that the report concerned. Although the IAEA takes modest steps to avoid this, it is unavoidable under the present controls.

Finally, it should be noted that the IAEA does not teach languages to inspectors and does not assist inspectors to learn the language of the country which he inspects. The IAEA operates in four official languages of the United Nations and on a semiofficial basis in German. Often the inspector cannot communicate with the party being inspected, except via a representative of the national authority or Euratom, who is conducting a parallel inspection. This occurs more often than not, I would estimate. A result of language difficulties is poor communications. For example, failure of an operator to carry out a commitment made to an inspector may be blamed on not having understood.

ILLEGIB

3. MISSIONS TO THE AGENCY

Member countries of the Agency provide liaison to the Agency by way of their Missions to the Agency. Some countries have a special staff for this purpose, such as the U.S. One of the comments one hears in Vienna is that "You can't get anything done around here without going to your Mission." As an example of this, I witnessed a case where a non-U.S. inspector was promoted to P-5 (ca. $55,000 p.a. tax free) while I was on inspection travel with him. He received two telegrams of congratulation concurrently. One of these came from his Section Head at the Agency; the other came from his Mission.

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In my experience, I discerned inadequancy in the safeguards area. Most U.S. inspectors did not feel supported by the U.S. Mission.

4. SUBSIDIARY ARRANGEMENTS

A country that has signed the NPT in time concludes an agreement with the IAEA modeled after INF/CIRC 153. This agreement specifies in greater detail than that found in the NPT how safeguards are to be applied in the state. In addition to this agreement, subsidiary arrangements are concluded which specify how safeguards are to be applied. These subsidiary arrangements consist of a general part and of detailed attachments which specify how safeguards are to be applied to "facilities" and to "other locations" where nuclear material is present in small quantity.

4.1 Design Information

The facility attachments are concluded on the basis of "design information" (DI) submitted by the State. In my experience, the headquarters review of the DI and its field verification has been inadequate.

The Agency has the right to carry out DI verification, but often only three weeks notice may be required to be given before an installation receives nuclear material from the time the DI is submitted. Thus, a review of the DI may not be possible and may not be permitted. Such a review is important in many types of installations, to assure that there are no undeclared diversion routes, connections to sampling stations, by-pass lines, etc. For example, once a reprocessing plant becomes radiologically contaminated, there is no further chance for a DI review. I am not aware of any DI review of any reprocessing plant.

Also, many tank calibrations in a reprocessing plant can be performed only before an area becomes contaminated. Although verification and witnessing of tank calibration is not a design information review activity per sé, it can only be performed before nuclear material is introduced. Due to the short time interval between the submittal of the design information and the introduction of nuclear material, as well as because the plant operator simply does not permit the witnessing of the calibrations, the verification activity is only rarely carried out by the IAEA. This lack of assurance of tank calibrations introduces an additional uncertainty in the quantities of nuclear material, transfered and in inventory.

In the case of facilities involving sensitive information, such as reprocessing plants and enrichment plants, DI review is typically not permitted, although newsmen may be given tours. This shows the seriousness with which the IAEA is regarded in the real world.

Another shortcoming in the design information is its completeness. For example, in comparing the information on piping and tanks available at one reprocessing plant, WAK, with that provided for another, the PNC reprocessing plant, one finds that the PNC information is orders of magnitude more detailed than in the WAK case. In comparison, the WAK data is scant and probably inadequate. This is because the diversion paths and falsification scenarios possible in a reprocessing plant can only be addressed with complete knowledge in hand regarding by-pass and recyle routes, and storage locations.

In spite of, or without regard to, the adequacy, completeness, or examination of the design information, negotiations are conducted to conclude a facility attachment, to specify how an installation will be safeguarded. The country may, however, fail to agree with the Agency on the facility attachment. Years may pass.

4.2 Facility Attachment

When the facility attachment (F/A) is concluded, it is a consensus document which may permanently emasculate efforts to safeguard the installation. For example, the "actual required inspection effort" (ARIE) agreed to may be barely enough to cover scheduled visits and may leave no time to resolve discrepancies or complete tasks that took longer than anticipated. And ARIE is taken very seriously. Quite often, ARIE is about 10% of "maximum required inspection effort" (MRIE), which is specified in the "Blue Book."

Another area, particularly in the case of bulk handling and reprocessing plants where the F/A falls short is in not requiring that a "tag list or "list of inventory items" showing the gross, tare, net, element, and fissile isotope weights be made available after the "physical inventory taking" (PIT) of the operator of the installation. This tag list would be used by the inspector in his physical inventory verification (PIV). Since a tag list is often not required, very often the inspector is left to take the inventory, rather than to verify it. This is an often impossible task for the inspector, due to his limited time and manpower.

When a tag list is required by the F/A, the specific bits of information required, such as element and isotopic weights, are not called for. Again, the inspector is defeated. The reason the inspector is defeated in such circumstances is that where the operator provides the tag list only after the inspector completes his verification activities, the operator is in the position to correctly report those items that he observed the inspector to have verified, but to falsify the reporting of those items that the inspector did not verify. Thus, the operator is in a position to falsify the material balance.

Typically, a stratified list of items on inventory is required prior to the PIT, for planning purposes. A record of actions taken during the physical inventory including a list of batch data is required. The list of batch data need not be available at the PIV, and further, is usually inadequate as a basis for verification, because individual items are usually not listed. Unfortunately, the distinction between PIT and PIV is often not comprehended.

Another shortcoming of the F/A is that it usually includes a clause such as, "inspection shall be by observation of the State authority's inspection only, unless observation is inadequate to permit the drawing of independent conclusions." This clause frequently leads to haggling and loss of precious time during the inspection as to what activities are actually permitted by the F/A, and often, to the failure of the inspector to carry out necessary activities.

The shortcomings mentioned above are not an exhaustive list, but should serve to illustrate that the inspector is often doomed from the start by an inadequately negotiated facility attachment.

4.3 Subsidiary Arrangements-General Part

This part of the subsidiary arrangements specifies how a State formally reports the inventory and transfer activity to the IAEA. There are various categories of "inventory changes" permitted. One of these is the "measured discard."

Usually there is a specified limit on the amount of measured discards which may be discarded by the operator; such a limit may be, for example, 0.01 Kg effective per month per bulk handling or reprocessing installation, of material that is "disposed of in such a way that is not suitable for further nuclear use." When the amount exceeds the limit, the state is required to consult with the Agency before discarding takes place. Since the quantities and physical form of nuclear material reported to have been disposed of are typically not verified because the discards occur at times when no inspector is present, a credible diversion path is constituted by measured discards. This situtation is compounded in severity, it would seem, in a country such as FRG, where all waste is transferred to a central waste handling facility, which is not subject to IAEA safeguards. Once the waste goes to the central facility, pending resolution of the ultimate disposal of waste issue, it is "out of sight, out of mind." Why IAEA is not permitted to inspect such a waste handling facility is unclear. At the time that the nuclear material is sent to such a facility, it often is suitable for further nuclear use.

Another category of waste removal is "retained waste." Retained waste is defined as "nuclear material which is generated from processing or an operational accident, which is deemed to be unrecoverable for the time being, but which is stored." Waste in this category, without regard to quantity, may be transferred out of inventory. Such waste no longer appears in the operator's book inventory records and is not reported to IAEA in the physical inventory list after the operator's physical inventory taking. Only by searching back to the time the transfer to retained waste occurred would a record be found. It is, therefore, "out of sight, out of mind." Considerable quantitites of "retained waste" are stored at some bulk handling installations, but are not periodically verified by an IAEA inspector.

5. RECORDS AND REPORTS

Under this heading, I discuss the records of the installation and the reports that are submitted by the installation via the State (or regional authority such as Euratom) to the Agency.

5.1 Records

The Agency requires a system of records and reports in the facility attachment. The records are of two kinds, namely, (1) accounting records and (2) operating records.

I saw great differences between the quality of the accounting records from State to State and, within a State, from installation to installation.

I found, for example, that in FRG the records were not organized conveniently in the sense that in order for the inspector to perform a simple audit of the records, considerable time had to be wasted to summarize the activity that occurred since the previous visit. For example, in one major facility, the records were kept according to financial account. There were about 300 of these. There was no general ledger summarizing activity in the several hundred accounts, but there were numerous transactions within and between accounts. I found that to effectively carry out my audit, I had to create my own general ledger. During each inspection, I wasted several days in this activity. The facility simply saw no need to keep a general ledger, for its purposes. The point is that the operator or the State can cause the inspector to waste a lot of his limited time.

With regard to operating records, I also found deficiencies. For example, in one facility, there was no record kept of the final disposition of plutonium samples. Such samples were said to be returned to the process. But, one would expect a record kept showing date, time, and identity of the reintroduced samples. The Agency simply does not concern itself with material control at that level of detail.

5.2 Reports

I noted that neither in FRG nor in Japan, nor elsewhere as far as I know, did a system of material transaction reports exist, such as does exist in the U.S. with the form NRC/DOE-741. This system is effective, in that serially numbered forms are issued by the shipper of nuclear material and are acknowledged by distribution of return copies by the receiver. These forms are matched by computer in the U.S. system to detect material missing in transit and to flag shipper-receiver differences. In the absence of such a system, an item missing in transit or shipped to an unauthorized recipient could go undetected.

The Agency system, however, requires the reporting of transactions to the Agency one month after the month in which they occurred. One way to detect material missing in transit or not shipped to the stated recipient, after the fact (but rather shipped to an unauthorized or undeclared recipient), is to compare each shipment declared as shipped in the monthly report with each shipment declared as received. When I arrived at the Agency in 1977, I found that this was being done in summary form, well after the fact, by a clerk, in the case of Japan under the Far East Section. However, with the advent of magnetic tape reporting with NPT in January, 1978, this comparison, known as "running the transit accounts," became the responsibility of the Section for Data Processing Operations, Division of Safeguards Information Treatment, in the Department of Safeguards. This Section has responsibility for all NPT reporting. It was claimed that it was impossible to run the transit accounts because sufficient design information for all installations to permit preliminary error screening of reports had not been provided by the inspectors. Thus, the emphasis changed from accounting to that of the use of the computer as a device of interest in its own right. At a later date, it was claimed that transit accounts could not be run because batch numbers provided by shippers were not always the same as batch numbers provided by receivers. Another problem, in the case of EURATOM reporting, was that France did not report to the Agency except for the one facility under safeguards, so that transactions between France and another EURATOM country could not be checked. Thus, for a variety of reasons, I was repeatedly told that the transit accounts could not be run. It was our belief, in EURATOM section of IAEA, however, that transit accounts were run by EURATOM, EEC, Luxembourg prior to the dispatch of the monthly reports to the Agency. On one occasion, I was granted a special, nonroutine check of transit accounts, due to absence of supporting records. At that point, DIT was willing to entertain a special request. Several months elapsed in the course of running transit accounts for a single installation. I learned that there were shipments and receipts that did not match. We informed EURATOM, Luxembourg, who replied that they had not detected this due to a computer malfunction. This episode lead me to believe that Luxembourg was not running transit accounts either. Thus, the Agency had, and presumably still does not have, any routine assurance that a stated shipment to an installation within a State or a group of States, such as EURATOM, ever arrived. That is, with limited exception, when the Agency checks the reports of installation X, it does not compare those reports with the reports of other installations which reported transactions with installation X. Thus, it only verifies the internal arithmetic consistency of installation X's reports, in effect, treated in isolation.

Another problem area for the Agency has been its Advance Notification of Internation Transfer reports. These are not always reconciled either. And, when they are reconciled, they often don't agree, due to inability to match shipper's and receiver's reports.

Finally, the DOE sends copies of Form NRC-DOE-741 for international transfers to the IAEA. These also are gracefully allowed to pile up "in the corner." It seems that the IAEA does not need them.

6. INSPECTIONS

Although I have discussed inspections in other sections of this report, I will provide some background here as to what an inspection consists of and what it can and cannot do for various types of facilities.

During my employment with the IAEA, the types of installations that I inspected included reprocessing plants, conversion and fuel fabrication facilities (bulk handling facilities), reactors and critical facilities of various types, and laboratories.

The approach that I will employ here is to explain first how IAEA safeguards generally, comment briefly on the generic safeguards techniques, and then explain how safeguards are applied at various types of facilities.

6.1 How NRC Safeguards Generally

INF/CIRC 153, The Structure and Content of Agreements Between The Agency and States Required in Connection With the Treaty on the Non-Proliferation of Nuclear Weapons, popularly known as the "Blue Book," articles 28, 29, and 30, provides the following statement:

> 28. The Agreement should provide that the objective of safeguards is the timely detectio of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection.
>
> 29. To this end the Agreement should provide for the use of material accountancy as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures.
>
> 30. The Agreement should provide that the technical conclusion of the Agency's verification activities shall be a statement, in respect of each material balance area, of the amount of material unaccounted for over a specific period, giving the limits of accuracy of the amounts stated.

It is important to note that in the context of article 28, "diversion" should not be equated with "removal." This is an important distinction, because typically, an Agency inspector is concerned with diversion in the narrow sense as removal.

With regard to article 29, one sees that the basis of IAEA safeguards is:

1. material accountancy
2. containment
3. surveillance

6.2 Material Accountancy

In practice, "material accountancy" refers to the means by which the Agency verifies the presence of nuclear material that should be present at an installation based upon records and reports. This system is, in itself, made difficult because the reports occur several months after the actual movement of nuclear material. Thus, the Agency's material accountancy typically consists of verification of the arithmetic correctness of the operator's records, verification of the authenticity of the records by means of shipping documents and the like furnished by the operator, and several months after the fact, cross-comparison of this information with reports of the same operator, which he sent via his national system to the Agency on magnetic tape. As mentioned previously, the Agency has thus far found it virtually impossible to inter-compare an operator's reports with reports of any other operator, to verify the veracity of the reports, especially in the case of States under NPT.

Article 30 refers to the so-called MUF statistic, which is the operator's statement of the amount of nuclear material, based upon his physical inventory taking, that is apparently discrepant from the amount that is supposed to present, based upon his records over a period of time. The LE (MUF) is typically not calculated, although the Agency has good intentions of calculating an approximate LE (MUF) in the future.

Very rarely the Agency calculates a $\hat{D}$ statistic, which is the inspector's MUF, based upon his verification of the operator's statement. This is typically incomplete, because the inspector rarely, if ever, measures all components of the operator's material balance closure and does not possess the information necessary to perform a realistic calculation. The Agency just does not have the manpower to do much verification and often does not have time to take as many samples, even with a willing operator, as it believes necessary, of even the ending inventory component.

In the best of all possible worlds, the MUF statistic is the closest that the Agency verifies the material balance. In reality, it falls very far short of what is intended, because of holes in the system which provide the MUF.

Because of the inherent difficulties of the MUF statistic, the Agency has attempted to implement a system of "timely detection" at sensitive facilities. Such implementation is, at the present time, far beyond the capabilities of the Agency to implement and beyond the willingness of the countries to undertake. It goes beyond the Blue Book, some believe, and would require massive amounts of sampling and verification, and real-time knowledge of the amounts of nuclear material moving between installations, rather than after the fact notification. At the present time, such efforts are only in their early stages.

6.3 Containment and Surveillance Measures

Article 29 also refers to containment and surveillance measures. At the present time, this refers primarily to seals in the containment category, and cameras in the surveillance category.

In the case of seals, the Agency mainly uses the so-called "IRS Type-E" seal. This seal has been around for a long time, and as early as about 10 years ago, efforts were underway by at least one foreign government to "break it." The seal has been "beefed up" by the Agnecy, but is basically an old device that requires labor intensive "post-mortem" examination, which verifies that the seal removed is the same one that was originally emplaced, rather than a counterfeit. The post-mortem examination is not necessarily capable of determining whether the seal was sureptitiously opened and then reassembled.

The Agency also uses paper seals. According to expert authority, these seals are useful for only a few hours at best, because they can be removed and replaced, and also because they can be duplicated by a good printer.

There are several other seals around, but none of these have been used, except in limited tests.

In any case, a second basic shortcoming of the use of seals is that the item sealed can often be accessed by bypassing the seal.

Camera surveillance is of two types. One is the film camera, such as an 8mm Minolta. These are typically used in pairs in a sealed enclosure. They are set, in a power reactor, to each snap a picture at 15- or 20-minute intervals, so that, at best, there is only 7 to 10 minutes between snaps. These are intended to detect movements of large items, such as a cask bearing fuel assemblies.

The other type of camera is the TV camera, which turns on at predetermined intervals and snaps 8 or so frames.

Generally, the quality of pictures obtained is extremely poor. Further, there have been numerous failures. There have been significant improvements recently in reliability, but failures still occur at an alarming rate.

One scenario, which has appeared in several literary sources, is the placement of a photograph of the viewed scene in front of the camera. This is plausible, because the illumination level normally changes as lights are turned off and on, and the frames typically jump around. But there are also more sophisticated ways to defeat the camera.

A basic difficulty associated with containment and surveillance devices is that the device is not under the continuous observation of the inspector, as would be an alarm system in an industrial setting.

In my experience, another basic difficulty with both film type and TV type surveillance is that the image is often typically not clear enough to be meaningful. Typically, many activities occur on the film that are rather baffling. Also, people stand in front of the camera and barriers are erected that block the view. The camera may be moved. The lights may go out. And, often, the camera simply fails. Further, the interval between pictures is intended to protect against a known scenario, such as a cask movement to remove fuel, where it is assumed that the Agency really knows how long the activity will take, so that the movement would be caught on film, whereas it might not really be known.

6.4 Safeguards at Specific Types of Installations

6.4.1 Reprocessing Plants

During my employment with the IAEA, I inspected at the reprocessing plants of PNC at Tokai Mura in Japan, GWK (WAK) at Karlsruhe in FRG, and once, COGEMA at Cap de la Hague in France. The first two facilities were under "continuous" inspection regimes. The latter facility only stored fuel under safeguards, but had not reprocessed any of it. Basically, uncertainties associated with reprocessing plants involve, at best, a several per cent uncertainty of MUF. At worst, a lot of other possibilities open up, including the possibility that an installation might reprocess undeclared irradiated fuel, or understate the plutonium content of the declared fuel. One installation was rumored to have posessed an undeclared, never used, natural uranium storage pond, for example. In a reprocessing plant, therefore, one should look for hidden fuel as well as account for declared fuel. But the Agency does not attempt to find undeclared fuel. For example, if a plant operator says that no fuel will be processed for one month, the Agency will stop sending inspectors for a month.

In the case of understating the plutonium content of the input dissolver solution, the scenario would entail diverting some of the input dissolver solution to avoid measuring it in the input accountability tank. At a later time, the diverted solution would be transferred from its location in, say, a tank of the rework system, where it had been stored, to the extraction and purification systems, in order to extract the plutonium, at a time when the plant was declared "down" and not under inspection. The uranium solution needed to make up for the diverted uranium contained in the divertered dissolver solution would be replaced from uranium in storage, since uranium quantities are known from fuel element manufacturer's data. This type of scenario is simply not covered by IAEA safeguards. IAEA rather bases its safeguards primarily on operator's data supplemented by camera surveillance. I know of no case where recycle acid was verified, for example, or where valves were sealed to prevent undeclared transfers. Samples are taken of the input and output solution, but are drawn from sample ports that have not been verified by design information review, so that one can't be certain where the sample came from. Further, the samples are handled in the plant by the operator and may be prepared by the operator, before shipment to Vienna. In one case, the operator and country refused to allow shipment of samples for a year on the grounds that it was illegal due to the absence of an approved shipping container. Finally, after the samples had been in the operator's control for a year, the Agency was asked if they could be discarded, because they had been standing so long. The Agency agreed.

In addition, because the samples must be diluted before shipment, analytical accuracies are reduced at Seibersdorf.

In the case of the COGEMA facility, there is no input accountability tank, so that input accountability will probably have to be based on reactor data.

An independent means of assessing the plutonium content of spent fuel is by burnup calculations and isotopic correlation techniques. Unfortunately, burnup calculations, which require verification of reactor operator's data, is not even done on an occasional basis by the Agency. Neither are isotopic correlation techniques applied. The Agency simply takes the word of the operator as to the plutonium content of the spent fuel and checks that against what it finds at the reprocessing plant, subject, of course, to the limitations of that finding.

6.4.2 Research Reactors

In the case of research reactors, as in power reactors, the potential exists for undeclared breeding of plutonium and/or U-233. In the research reactors that I inspected, of which there were several, there were no containment or surveillance measures provided to address these possibilities, nor am I aware of any measures which would have been effective. Typically, research reactors are inspected infrequently, perhaps once annually. The Agency's camera surveillance would be unable to distinguish between irradiation of fertile material samples to produce plutonium or U-233 and irradiation of medical samples, for example, even if a camera could run unserviced for one year.

One medical use of research reactors, incidentally, is irradiation of highly enriched uranium to produce molybdenum-99, which is extracted and decays to technecium-99. The Tc-99 is used for medical scanning for tumors. After irradiation, most of the U-235 still remains in the target, which is typically mixed in concrete, prior to ultimate disposal. The highly enriched uranium could be extracted, however, as a potentially attractive source of kilogram quantities of weapons grade material prior to the mixing with concrete. This extraction would probably not be detected by IAEA safeguards, since an IAEA inspector may only visit such an installation annually for one day.

6.4.3 Critical Facilities

One critical facility which I visited contained hundreds of kilograms of low exposure, weapons grade plutonium. A facility of this type is sensitive from the abrogation scenario standpoint where, under some sort of immediate threat, the country simply takes possession of all the nuclear material for immediate manufacture into nuclear weapons components. About 100 Kg of this material was under IAEA seal. During biweekly "time detection" inspections, the inspectors would visually check the type E seals on this material, in spite of the fact that these seals can be counterfeited, so that only post-mortem examination at headquarters is meaningful. I once demonstrated to the operator and the inspection team leader that, due to the absence of some needed holes in the lid and body of the container, the sealing system was inadequate; the containers could be opened, the material removed, and the lid replaced simply by removing two bolts, without disturbing the seal. I also brought up this problem in Headquarters upon return from mission. However, this situation was not corrected, possibly because Agency personnel had collaborated with the operator on the method by which the seal would be applied in the first place and felt partially obligated to go along with the outcome, when the operator said that the holes could not be drilled.

The method of safeguarding a major critical facility entails monthly sampling and remeasurement of unsealed fuel plates. The fuel plates can be remeasured to within about 3% by NDA. Perhaps 1% of the material could be removed by, say, drilling or remanufacture of the plates, without detection likely but this type of scenario is considered unlikely. Chemical analysis by the agency for highly accurate measurement of a suspect fuel plate is not foreseen in the usual facility attachment.

6.4.4 Power Reactors

Power reactors are of various types, and can be classified according to whether on- or off-line refueled, types of moderator and coolant, whether natural or enriched uranium, etc. On-line refueled reactors are considered more sensitive and safeguarding was primarily by counting all fuel elements and check of serial numbers against the invoice of unirradiated fuel elements. Identification of serial numbers on spent fuel is usually impossible. Although there is work underway, especially in Canada, to automatically count fuel elements, this was not done in my experience. Counting of power pulses on a chart was the means of verifying the number of fuel elements changed in the core in one instance, but "noise" pulses on the chart made this of dubious value. Camera surveillance was intended for loadout pond, to detect undeclared loadout of irradiated fuel by that route.

In the case of off-line refueled reactors, camera surveillance was used in the spent fuel pond area to detect undeclared loadout and seals were employed on the reactor head and/or at the entrance gate to the spent fuel pond between refuelings. Fuel elements were counted and serial numbers on unirradiated fuel elements were verified at inspections. In both cases, physical inventories occurred at annual to 18-month intervals. Nondestructive assay verification was permitted at that time. Inspection frequency ran from 3-month to 6-month intervals.

Verification of reactor operating history was by reviewing strip charts of power, steam flow, temperature, or neutron flux. Typically, a maximum of two charts were permitted to be reviewed. Access to the control room was not permitted. Rather, the charts would be removed and brought to the inspector for review in a meeting room.

The possibility of irradiation of additional fuel contained in normally nonfuel-bearing structural components of the fuel assemblies was not covered by the inspection approach of power reactors, although this has been discussed in a report on technical assistance to the Agency by the U.S. The possibility of an adaptation to facilitate the irradiation of fertile fuel by other means was also not covered. For example, there is no close inspection of the reactor vessel prior to operation or at the time of maintenance to detect a shuttle system. Burnup calculations to determine the amount of plutonium in spent fuel were not verified, nor were power monitoring devices verified.

6.4.5 Fuel Fabrication, Conversion, and Unirradiated Scrap Recovery

This part of the fuel cycle centers around the fabrication of fuel for the various types of reactors and critical assemblies.

In larger facilities, the IAEA makes approximately monthly inspections of one day duration, performs an annual physical inventory verification of several days' duration and, where large quantitites of direct use material are present, more frequent inspections may be made. A basic difficulty that I observed here are unwillingness to take samples and ship them to the Agency's Seibersdorf Laboratory, on the grounds of cost or shipping regulations. In one European installation that I was aware of, the operator wanted $1000 per sample from the Agency. A problem that I encountered was unwillingness to allow the Agency to use nondestructive assay equipment that required small radioactive sources in their operation. The operator claimed that national regulations did not permit the presence of those particular sealed sources in his plant, in spite of the presence of large quantities of plutonium. In that installation, the operator and State had refused to permit the Agency to apply timely detection continuous inspection at the facility by virtue of its contention that inspection was limited by the Blue Book to flow and inventory key measurement points. As a result, the Agency "punished" the State by reduced inspection to 2- or 3-month intervals. In this case, the State did agree after several years to the timely detection inspections on a trial, informal basis to parts of the facility. But, without full cooperation and a serious investment in computer hardware and extensive accurate measurements, which I have yet to see, timely detection is of limited value.

The Agency's approach to verification is based upon a report, BNWL-1852, "Example of Verification and Acceptance of Operator Data - Low Enriched Uranium Fabrication Plant," Battelle Pacific Northwest Laboratory, Richland, Washington, August 1974. This report provides the framework for the concept of verification of strata of flows into and out of the plant, as well as in beginning and ending physical inventories. A material balance for a period of time is formed by the plant operator from the following components on the right side of the equation:

$$MUF = BI + A - R - SR = EI$$

Where =	MUF	=	material unaccounted for
	BI	=	beginning physical inventory
	A	=	additions to inventory
	R	=	removals from inventory
	SR	=	shipper-receiver difference
	EI	=	ending physical inventory

If everything could be measured perfectly and there were no mistakes or unaccounted for losses or diversion, MUF would come out equal to zero for a material balance period. But due to normally occurring errors of measurement, MUF is typically not zero, but indicates apparent "loss" or "gain." The idea is to determine whether the MUF is only due to measurement error or also due to unaccounted for loss, diversion, or a mistake.

Normally, the components of the material balance will be composed of several strata each. For example, BI may be composed of good substrate material, the product material which is manufactured from the substrate, scrap, and waste. The Agency, ideally, verifies each stratum of each component of the material balance. In reality, it seldom is able to verify each component. In any case, it attempts to detect a diversion of a significant quantity of nuclear material by verifying a sufficient number of items in each stratum to provide a desired power of detection, (1-B), of the loss of a significant quantity with a tolerable false alarm rate, α. A theorem is derived which addresses the problem of whether the diversion of a significant quantity, if "partitioned across" (took place in) more than one stratum, would be detected with adequate power. The theorem shows that, if diversion were partitioned across more than one stratum, the power of detection would be as great as or greater, by virtue of a defect being found in at least one stratum, than if the diversion of the significant quantity had occurred all in one stratum.

The falacy inherent in this approach is that there will often be at least one defect due to a mistake. Thus, if any mistake is found, the Agency must alarm to the hypothesis of diversion by partitioning. And there are often false alarms (mistakes). This is even more serious when one considers that the country is the adversary, so that partitioning across all installations in a country must be assumed if any alarm occurs. Since it is patently not feasible to alarm to the possibility of diversion by partitioning across the State whenever a mistake is found, the conclusion that one reaches is that the Agency is incapable of detecting the diversion of a significant quantity or of several significant quantities, by partitioning, in any State with a moderate to large nuclear energy establishment.

7.0 What Materials This Report Has Concerned

IAEA safeguards are aimed at the control of certain direct-use materials, namely: high enriched uranium, U-233, and plutonium; and certain indirect-use materials, namely; low enriched, natural, and depleted uranium and thorium which can be converted to direct-use materials. IAEA safeguards do not control uranium ore, neptunium, and a number of other materials which are controlled in the United States by DOE and/or the NRC. Uranium ore, for example, can be converted rather simply to uranium in a form that is an indirect-use material. Absence of its control is probably one of the glaring weaknesses of international safeguards today.

A large LWR produces roughly 15 Kg of neptunium-237 per year, according to the NASAP study. The unmoderated, spherical, critical mass of neptunium-237 is roughly 60 Kg. Its control will probably be required in the future.

8.0 Summary

In this report, I have attempted to describe how IAEA safeguards work and some of their weaknesses. I have not addressed all issues; there are many which are presently the subject of R&D efforts by several countries, for example. But I hope that I have identified some of them. I think that it is clear at this point that there are not many simple solutions and that a great deal of effort and commitment of all parties will be required to address these issues.

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